

Research on Optimization of Logistics Supply Path Selection Based on Genetic Algorithm

Lin Zhang^a, Ning Wang, Chengtao Zhang

Air Force Engineering University, Xi'an, China

^a 2662290150@std.uestc.edu.cn

Abstract. Aiming at optimization of multi-source and multi-sink path selection of logistics supply and considering the limitations of distance, time and cost, this paper, with the goal of minimum obstruction strength, constructs a multi-source and multi-sink path optimization model under the influence of multiple factors, and gives a genetic algorithm to solve the model and make analysis on the examples. The results show that the proposed algorithm has achieved good effects, which provides new solutions for the selection of this path.

Keywords: Multi-source and Multi-sink, Path Optimization, Genetic Algorithm.

1. Introduction

For the shortest path in the operational research, the dynamic programming method is commonly used. However, it is required to solve the generalized path obstruction strength of each path, and then calculate it accumulatively. In the case of lots of nodes, there will be a large amount of calculation [1]-[3]. Especially when the multi-source and multi-sink path optimization needs to be considered according to different situations, it is even more difficult to calculate by the dynamic programming method.

Because of its simple structure, global optimization and potential parallelism, genetic algorithm can get the ideal solution of multi-source and multi-sink path optimization model of single transportation mode under the influence of multiple factors [4].

2. Path optimization model

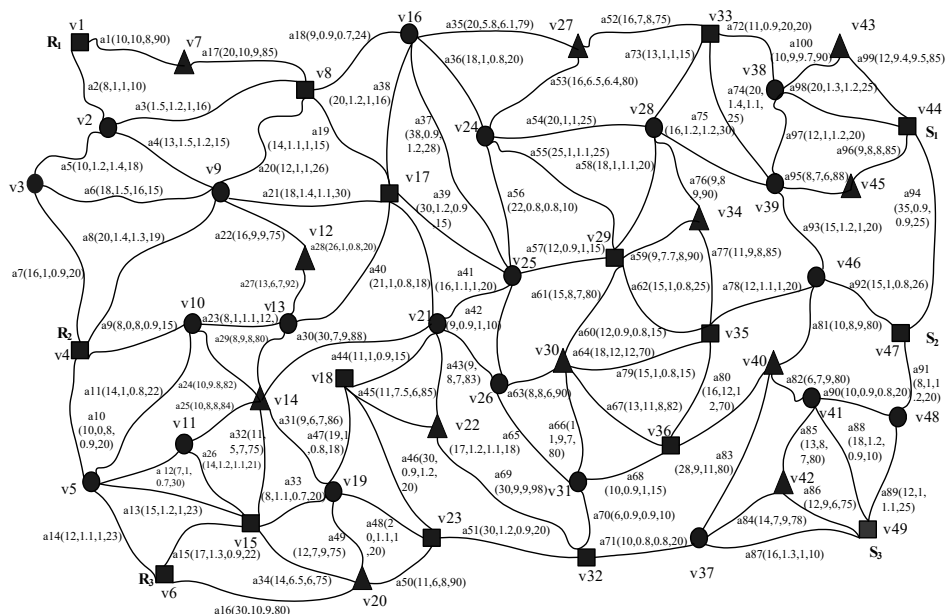


Figure 1. Transportation Network Diagram of Spare Parts from a Storage Point R to a Supply Point S

Suppose the traffic network from a logistics storage point R to a supply point S is as shown in Figure 1. There are three storage points: R_1 , R_2 , R_3 three supply points to be provided S_1 , S_2 , S_3

circles, squares and triangles in the Figure are all nodes. Squares represent "necessity-node", that is, the place where transportation detachment must pass, such as rest places and gas stations. Triangles represent "restricted point", that is, the place that is not allowed to pass during transportation, such as damaged roads and traffic limited sections. The network diagram from the origin "R" to the end "S" is marked as $G=(V,A,B)$. V represents node sets (special sections, important towns, transportation hubs, etc.), A represents arc sets (road sections), and B represents generalized obstruction strength of road sections and nodes.

2.1 Basic assumptions of the model

Cost, time and danger are the main constraint factors affecting the transportation path optimization of spare parts, while the constraint factors include path length, traveling speed, security warning and support cost, loader and so on. As each factor changes with the actual situation, the multi-objective problem of solving the generalized obstruction strength is transformed into a single-objective problem. The generalized obstruction strength of nodes and arcs (road sections) is defined by linear weighted method [5]:

$$B = a(w_s s + w_t t + w_d d)$$

Wherein a , path length (distance), also known as arc length;

s —cost that passes per unit distance (arc) or node;

t —time that passes per unit distance (arc) or node;

d —danger that passes distance (arc) or node.

w_s , w_t , w_d represents the weight of each objective, and $w_s + w_t + w_d = 1$.

To make the model fully consider the restricted points, necessity-nodes and the node order-preserving, the necessity-restricted points set V_f , the point set V_k , the front and tail node set V_c and V_e are established. There must be the front node $V_{i(i>1)} \in V_f$ that corresponds to the node $V_f^i \in V_f$. Wherein: $V_k \subseteq V$, $V_f \subseteq V$, $V_c \subseteq V$, $V_e \subseteq V$.

2.2 Establish the path optimization model

According to the analysis of transportation network diagram $G=(V,A,B)$, the path R to S the minimum obstruction strength B is optimal. Its mathematical model is:

$$F(B_{rs}) = \min B_r \text{ s.t.} \quad (1)$$

$$B_r = \sum_{(i,j) \in A_r} B(i,j) + \sum_{i \in V_r} B_i \quad (2)$$

$$V_k \subseteq V_r \quad (3)$$

$$V_f \subseteq \overline{V_r} \quad (4)$$

$$\text{If } \exists i \in V_e \cap V_r (i > 1), \text{ then } \exists j \in V_c^j \cap V_r \quad (5)$$

Wherein, (1) is the objective function;

$B(i,j)$ —Arc (i,j) road obstruction strength;

A_r —Path set;

V_r —Node set;

B_{rs} —The optimal path from R to S .

B_r —Overall path obstruction strength.

3. Algorithm

The solution of multi-source and multi-sink path optimization model based on genetic algorithm is described as follows:

Suppose that the basic information is shown as follows:

Information about logistics storage points S . Number: m ; Single storage point: $S_{j(j=1,2,\dots,m)}$.

Supply point information R . Number: u ; Single supply point: $R_{i(i=1,2,\dots,u)}$.

Path number $a: \{a_1, a_2, \dots, a_n\}$; Path resistance B ; Node number $v: \{v_1, v_2, \dots, v_n\}$, Path information W .

3.1 Population initialization

If the number of nodes in the road network G is set to be N , the number of genes on chromosomes is also N . This sets the genetic composition of chromosomes: Origin 1 is " R "; The intermediate node consists of two parts. Suppose that there are a total of m nodes, one part is composed of k other nodes, in which $0 \leq k \leq N-m-2$, and the other part is composed of all nodes in the set V_k ; Finally, the end is " S ". If $k < N-m-2$, pad "0" after the " S ", the total number of genes always is N .

3.2 Fitness function

$$F_{ti} = W_{t\min} / W_{ti} \quad (6)$$

Wherein: $W_{t\min}$ is the smallest of the generalized weights of chromosomes in the t generation population, that is, the optimal one. If the function value of fitness is larger, the path is better.

3.3 Chromosome selection

The method of roulette wheel selection is adopted.

3.4 Chromosomal chiasma

Thanks to node order-preserving, the selection of chiasma mode has a great influence on the algorithm performance. Therefore, two chiasma modes are selected. Suppose that there are two parent chromosomes $A(R12546S0)$ and $B(R234156S)$, node 2 is before node 4, and they have an "order-preserving relationship". Node 5 is a "necessity-node".

Single-point chiasma is adopted, with the steps as follows:

Randomly select two chromosomes A selected by two different parents. One chiasma point of B gene is located after " R " and before " S " of the two chromosomes to ensure that the " R " gene is not crossed.

Exchange two chromosomes and matching segments between chiasma A , B points in two chromosomes, thereby obtaining new chromosomes A_1 and B_1 .

Validity check after chiasma. If there are repeated nodes in A_1 (or B_1), that is, nodes outside the matching segments appear at the same time, the nodes outside the matching segment are replaced by repeated nodes in the matching segment corresponding to nodes at corresponding positions of another chromosome. Replace them repeatedly until no repeated nodes appear in the chromosome;

Order-preserving. The chiasma process to be carried out is shown as follows:

$$\begin{array}{lcl} A: & R & 1 \ 2 \ 5 \ 4 \ 6 \ S \ 0 \\ B: & R & 2 \ 3 \ 4 \ 1 \ 5 \ 6 \ S \end{array} \quad \begin{array}{lcl} A_1: & R & 1 \ 2 \ 4 \ 1 \ 5 \ 6 \ S \\ B_1: & R & 2 \ 3 \ 5 \ 4 \ 6 \ S \ 0 \end{array}$$

$A_1: R124156S$ $B_1: R23546S$ appears after chiasma, because there is a repeat point 1 in the chromosome A_1 . It is replaced with a point that is not included in the original chromosome B . For example, a new chromosome $A_2: R124356S$ will be gained by replacing it with 3. Then feasibility test is carried

out until the chiasma result is feasible. If the results are not satisfactory after replacement, chiasma points need to be re-selected. If none of the above methods are feasible, chromosomes need to be re-selected.

3.5 Chromosomal variation

Three types of chromosomal variation are used.

After randomly deleting an unnecessary-node in R and S nodes, add a "0" gene after the " S " node;

If the effective gene from " R " to " S " is shorter than N , add a node that is not in the gene and delete a "0" gene at the same time;

Exchange the nodes without the node order-preserving required, and then subject to order-preserving after variation.

In the process of operation, three ways can be used for variation at the same time, among which the best fitness value is preferred.

4. Simulation example results and analysis

See the information such as the distance of each road section, the transportation cost per unit distance and the time required for passing per unit distance in Table 1. Because logistics supply mainly centers on low cost, rapidity and safety, the values of the three weights w_d , w_t and w_s are 0.6, 0.3 and 0.1 respectively.

Based on the genetic algorithm, the gene length of 50, the population size of 100, the crossover rate of 0.8, the mutation rate of 0.05 and the maximum iteration times of 200 are selected. The results are as shown in Table 1.

Table 1. Optimal Path Calculated by Genetic Algorithm

Storage point	Supply point	Optimal path
R_1	S_1	$v_1 \rightarrow v_2 \rightarrow v_8 \rightarrow v_{17} \rightarrow v_{25} \rightarrow v_{29} \rightarrow v_{35} \rightarrow v_{46} \rightarrow v_{47} \rightarrow v_{44}$
	S_2	$v_1 \rightarrow v_2 \rightarrow v_8 \rightarrow v_{17} \rightarrow v_{25} \rightarrow v_{29} \rightarrow v_{35} \rightarrow v_{46} \rightarrow v_{47}$
	S_3	$v_1 \rightarrow v_2 \rightarrow v_8 \rightarrow v_{17} \rightarrow v_{21} \rightarrow v_{26} \rightarrow v_{31} \rightarrow v_{32} \rightarrow v_{37} \rightarrow v_{49}$
R_2	S_1	$v_4 \rightarrow v_{10} \rightarrow v_{13} \rightarrow v_{17} \rightarrow v_{25} \rightarrow v_{29} \rightarrow v_{35} \rightarrow v_{46} \rightarrow v_{47} \rightarrow v_{44}$
	S_2	$v_4 \rightarrow v_{10} \rightarrow v_{13} \rightarrow v_{17} \rightarrow v_{25} \rightarrow v_{29} \rightarrow v_{35} \rightarrow v_{46} \rightarrow v_{47}$
	S_3	$v_4 \rightarrow v_5 \rightarrow v_{15} \rightarrow v_{19} \rightarrow v_{23} \rightarrow v_{32} \rightarrow v_{37} \rightarrow v_{49}$
R_3	S_1	$v_6 \rightarrow v_{15} \rightarrow v_{19} \rightarrow v_{18} \rightarrow v_{21} \rightarrow v_{25} \rightarrow v_{29} \rightarrow v_{28} \rightarrow v_{39} \rightarrow v_{38} \rightarrow v_{44}$
	S_2	$v_6 \rightarrow v_{15} \rightarrow v_{19} \rightarrow v_{23} \rightarrow v_{32} \rightarrow v_{37} \rightarrow v_{49} \rightarrow v_{48} \rightarrow v_{47}$
	S_3	$v_6 \rightarrow v_{15} \rightarrow v_{19} \rightarrow v_{23} \rightarrow v_{32} \rightarrow v_{37} \rightarrow v_{49}$

5. Conclusion

Genetic algorithm is more efficient than dynamic programming method in solving multi-source and multi-sink path optimization of single transportation mode under the influence of multiple factors. However, it is advisable to carry out several operations and select the path with the least obstruction strength as the optimal path when genetic algorithm is used to optimize the optimal path. The practical operation proves that the model is reasonably designed and characterized by certain applicability and fast calculation speed. The result is the approximate optimal solution, which meets the actual needs.

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